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H03G 3/20

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H3G GCS

(56) Documents Cited

GB 2297446 A	EP 0464792 A2	EP 0464670 A2
US 5748262 A	US 5523801 A	US 5428839 A
US 5175883 A	US 4520507 A	US 4410864 A
US 4355414 A	US 4271433 A	

WPI Abstract Accession No. 95-121001 [16] and JP070046497 A (Sony) 14.2.95 (see abstract)

(58) Field of Search
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INT CL[6] H03D 7/02 7/14 7/16 , H03G 1/00 3/20 3/30 , H04B 1/26 1/28 , H04N 5/44
ONLINE:WPI,EPODOC,JAPIO

(54) Abstract Title
Digital terrestrial TV tuner

(57) A digital terrestrial TV tuner comprising a voltage tunable filter 22, an amplifier 24 for receiving a UHF signal, a voltage control attenuator 26 for attenuating the amplified signal, a voltage tunable bandpass filter 28 filtering the amplified UHF signal, a ring diode mixer 30 for down converting the attenuated UHF signal to an IF signal, a low pass filter 34 for filtering the IF signal, two series connected high gain amplifiers 36, 38 for amplifying the filtered IF signal, a SAW filter stage comprising a series connected first SAW filter 40, a buffer amplified 42, a variable gain amplifier 44 and second SAW filter 46 for filtering the amplified IF signal, a variable gain amplifier 48 for amplifying the filtered IF signal, a mixer 50 for down converting the amplified IF signal to a base band signal and a low pass filter or diplexer 54 for filtering the base band signal before passing it to an analogue to digital convertor 56. The arrangement gives improved selectivity and lower phase noise and distortion.

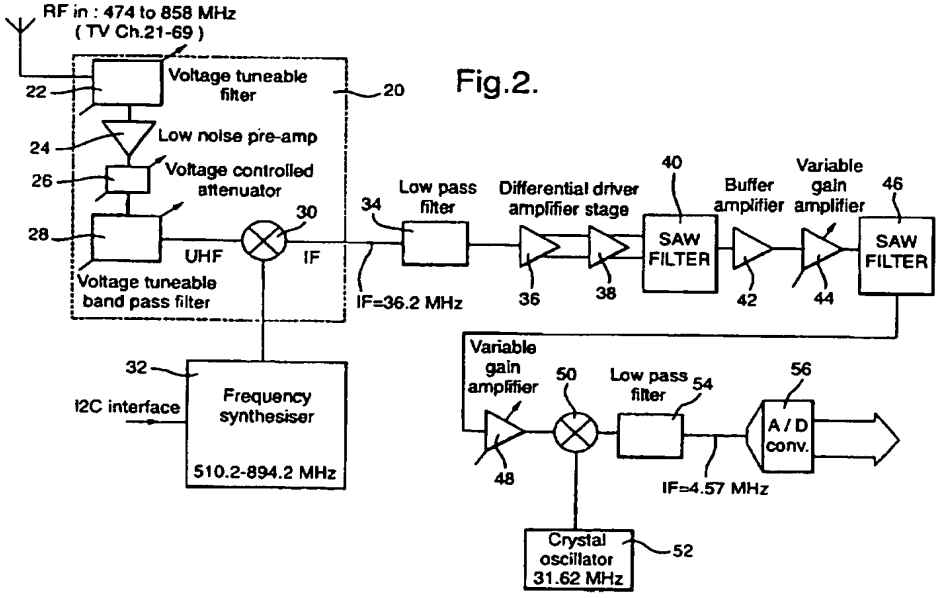
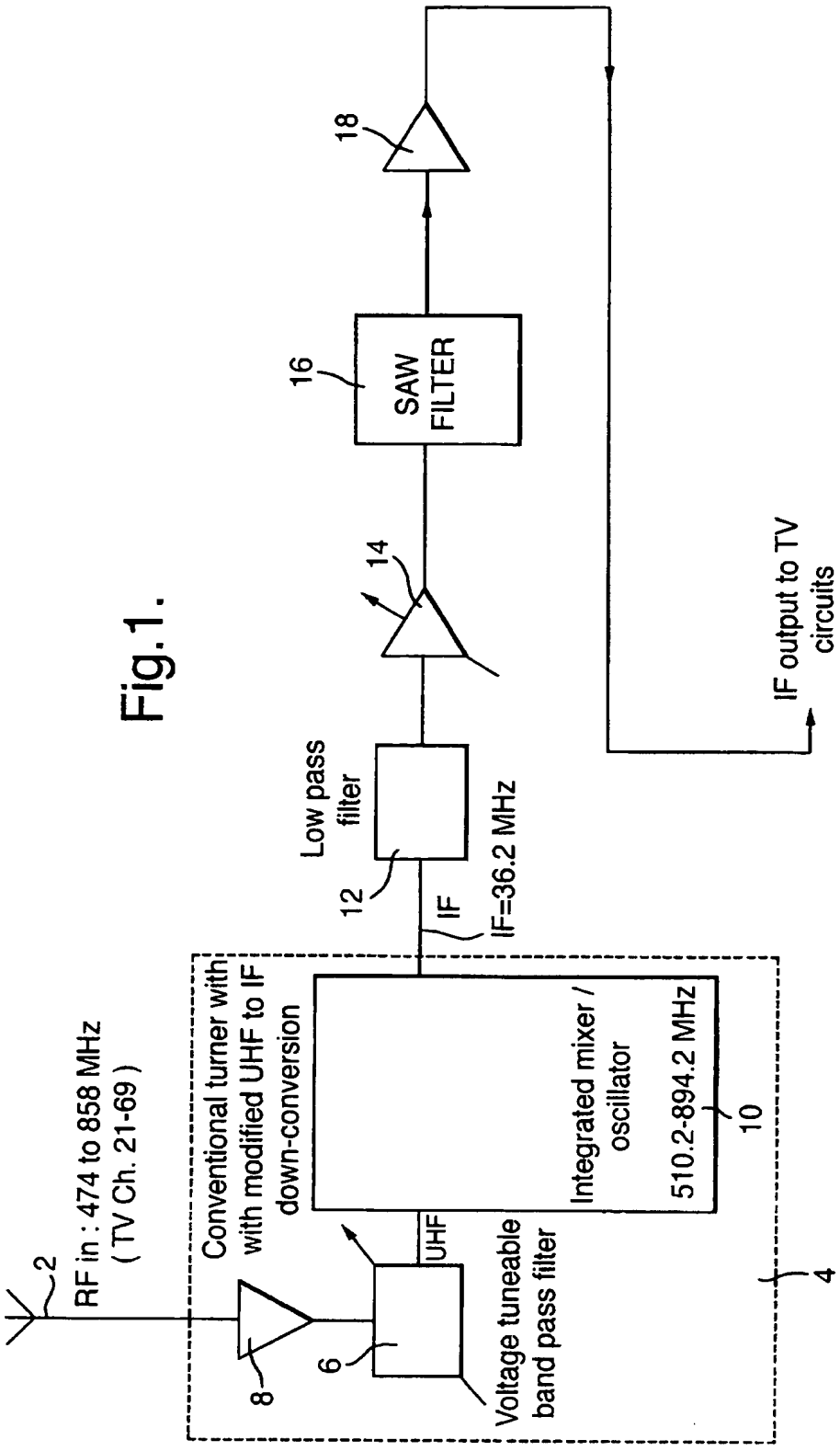


Fig.2.

GB 2 342 238 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.


2
RF in : 474 to 858 MHz
(TV Ch. 21-69)
Conventional turner with
with modified UHF to IF
down-conversion
8
6
UHF
Voltage tuneable
band pass filter
Integrated mixer /
oscillator
510.2-894.2 MHz
10
4
IF
IF=36.2 MHz
12
Low pass
filter
14
16
SAW
FILTER
18
IF output to TV
circuits

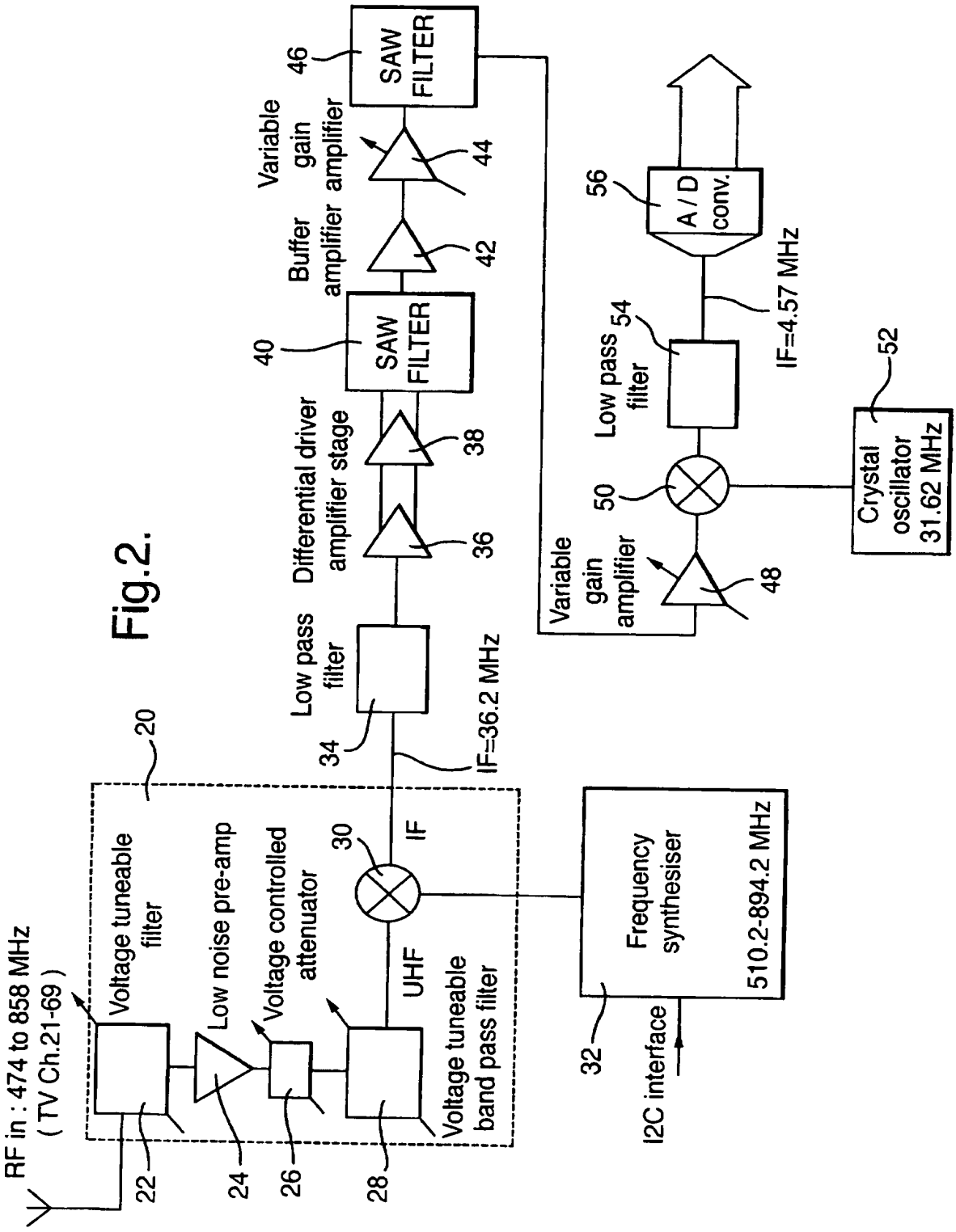

RF in : 474 to 858 MHz
(TV Ch.21-69)
22
Voltage tuneable filter
24
Low noise pre-amp
26
Voltage controlled attenuator
28
Voltage tuneable band pass filter
20
30
UHF
IF
34
Low pass filter
IF=36.2 MHz
36
Differential driver amplifier stage
38
40
SAW FILTER
42
Buffer amplifier
44
Variable gain amplifier
46
SAW FILTER
Variable gain amplifier
48
50
Low pass filter
54
IF=4.57 MHz
56
A / D conv.
52
Crystal oscillator 31.62 MHz
32
I2C interface
Frequency synthesiser
510.2-894.2 MHz

Fig.2.

DIGITAL TERRESTRIAL TV TUNER

The present invention relates to a digital terrestrial TV tuner, in particular having improved performance to previous tuners.

Tuners are known for the reception of terrestrial TV signals and Figure 1 of the accompanying drawings shows such a TV tuner.

The tuner is connected to an aerial or other suitable source of UHF radio frequencies in the range of 474 to 858 MHz corresponding to standard TV channels 21 to 69.

The tuner is provided with an input circuit 4 including a voltage tuner tracking filter 6 incorporating an RF amplifier 8 and an integrated mixer/oscillator that performs UHF to IF (intermediate frequency) down conversion.

In the rest of the tuner, the IF signal is passed to a low pass filter 10, an amplifier 12, a surface acoustic wave (SAW) filter 14 and a further amplifier 16, before leaving the tuner for further processing by subsequent television electronics.

Known terrestrial TV tuners, such as described above, are not suitable for the reception of the new digital services. In particular, the local oscillator used in the integrated mixer/oscillator used as the first down conversion stage from UHF frequencies to IF frequencies must have a lower phase noise than is normally possible.

Also, it is important to note that any digital signals will co-exist with analogue TV signals in adjacent channels and that the analogue TV signals are typically 20dB greater in power, such that a tuner requires much greater selectivity in the IF amplifier chain.

According to the present invention, there is provided a digital terrestrial TV tuner comprising:

an amplifier for receiving a UHF signal;

a voltage tunable bandpass filter for filtering the amplified UHF signal; and

a down conversion circuit for down converting the filtered UHF signal to an IF signal; the tuner further comprising:

a voltage controlled attenuator for attenuating the signal output from the amplifier and input to the voltage tunable bandpass filter.

The combination of the amplifier and attenuator enables a reduction in the noise figure of the tuner, whilst maintaining a high intermodulation distortion intercept value.

In this way, when large signals are input to the circuit, the attenuator reduces the signal presented to the bandpass filter and subsequent stages thereafter. This protects the tuner against distortion in the UHF parts, for instance the bandpass filter and down conversion circuit, whilst maintaining a good carrier to noise ratio at the output of the tuner. Previous tuners, in contrast, can be

overloaded by strong signals.

According to the present invention, there is also provided a digital terrestrial TV tuner comprising:

a UHF to IF down conversion circuit; wherein the down conversion circuit includes:

a ring diode mixer for multiplying an input UHF signal with a down conversion signal to produce an output IF signal; and

a local oscillator for providing the down conversion signal.

This mixer is capable of handling large input signals without distortion, such that the tuner as a whole can handle very large RF input signals without distortion. Furthermore, the use of a discrete component voltage controlled oscillator allows the generation of a very low phase noise RF signal for use by the mixer. This is not possible with previous integrated input circuits containing the functions of both the mixer and the VCO. The low phase noise means that the tuner can properly receive weaker signals than can be received by a tuner using an integrated input circuit.

According to the present invention there is also provided a digital terrestrial TV tuner comprising:

an input circuit for producing an IF signal from an input UHF signal;

an amplifier stage for amplifying the IF signal; and

a SAW filter stage for filtering the amplified IF

signal; wherein

the amplifier stage comprises:

two series connected high gain amplifiers.

By using the two high gain amplifiers, the level of the signal entering the SAW filter may be increased. This increases the dynamic range of the tuner and enables the tuner to receive signals over a wider power level range.

According to the present invention there is also provided a digital terrestrial TV tuner comprising an input circuit for providing an IF signal from an input UHF signal;

an amplifier stage for amplifying the IF signal; and

a SAW filter stage for filtering the amplified IF signal; wherein:

the SAW filter stage comprises:

a first SAW filter, a buffer amplifier, a variable gain amplifier and a second SAW filter connected in series.

The combination of SAW filters and amplifiers has the function of filtering the IF signal so that only the digital TV signal is allowed to pass through to following stages of the tuner despite the presence of TV signals, such as PAL signals, in adjacent channels. An advantage of this is that the analogue to digital convertor used subsequently in the tuner need use fewer bits for conversion. For example, with the use of only one SAW filter, the A/D convertor would need at least 10 bits to have the same performance as the tuner of the present

invention using an A/D convertor of 8 bits.

According to the present invention there is provided a digital terrestrial TV tuner comprising:

an input circuit for providing an IF signal from an input UHF signal;

an amplifier stage for amplifying the IF signal;

a SAW filter stage for filtering the amplified IF signal; and

an analogue to digital convertor for processing a signal derived from the SAW filter stage; wherein

the tuner further comprises:

a mixer for down-converting a filtered IF signal derived from the SAW filter stage to a lower IF signal for conversion by the analogue to digital convertor.

Preferably the mixer is a ring diode type mixer.

Such a mixer is able to process higher levels of signal compared with previously used devices, such that the dynamic range of the tuner may be increased.

Preferably, a variable gain amplifier is connected between the output of the SAW filter stage and the input of the mixer for amplifying the filtered IF signal provided to the mixer.

This may be used as part of a multiple AGC (automatic gain control). In particular, by using three or more control points, the dynamic range of the tuner may be increased.

Preferably a low pass filter is connected between the

output of the mixer and the input of the analogue to digital convertor for low pass filtering the lower IF signal provided to the analogue digital convertor.

The low pass filter or diplexer may be used to maintain a constant impedance at the output of the mixer whilst filtering out unwanted signals generated in the mixer. The diplexer has the benefit of increasing the dynamic range of the tuner without having to increase the number of bits used in the analogue digital convertor.

The invention will be more clearly understood from the following description, given by way of example only, with reference to the accompanying drawings in which:

Figure 1 illustrates a previous television tuner; and

Figure 2 illustrates a television tuner embodying the present invention.

As illustrated in Figure 2, a tuner is provided for the reception of digital terrestrial TV using the 2K carrier format.

An RF signal is received from an aerial 2 or other suitable source at an input circuit 20. In this preferred embodiment, the RF signal is a UHF signal of between 474 to 858 MHz corresponding to TV channels 21 to 69.

In the input circuit 20, the UHF signal is received by a tracking filter comprising a voltage tunable bandpass filter 22. The particular TV channel required for reception is chosen by varying the bandpass filtered by the filter 22 according to a control voltage. Thus, the

tracking filter 22 performs an initial course selection of the required band.

The filtered UHF signal is then amplified by a low noise high intercept point RF amplifier 24 and attenuated by a voltage controlled attenuator 26.

The amplifier/attenuator combination is used to reduce the noise figure of the tuner whilst maintaining a high intermodulation distortion intercept value. In the presence of large signals received by the tuner, the attenuator 26 reduces the signal past the subsequent stages and thereby protects the tuner against distortion.

The attenuated signal then passes to another voltage control tracking filter 28 which provides further and more selective filtering of the particular band for reception.

The filter UHF signal is then passed to a mixer 30 which is provided for down converting the UHF signal to an IF signal, i.e. an intermediate frequency signal of for instance 36.2 MHz. By varying the oscillator frequency used by the mixer, each of the required respective bands can be down-converted to the same IF frequency.

The mixer 30 is a ring diode mixer, preferably a passive diode ring double balanced mixer.

Such a mixer is capable of handling large input signals without distortion and allows the tuner as a whole to handle very large RF input signals without distortion.

The local oscillator signal used by the mixer 30 is provided by a discrete component voltage controlled

oscillator or VCO 32. This is preferably a low phase noise crystal controlled PLL synthesizer. This is capable of generating a very low phase noise RF signal for use by the mixer. A low phase noise means that the tuner can properly receive weaker signals than could previously be received by tuners using a combined integrated circuit mixer.

The IF signal is then passed to a low pass filter 34 of fixed cut-off frequency. This filter is used to prevent unwanted signals, including side bands produced by the mixer 30, propagating further through the tuner. This is particularly advantageous when used in conjunction with the high gain amplifiers to be discussed later. Unwanted signals could cause overloading of those latter amplifier stages.

The filtered signal is then passed to an amplifier stage comprising two amplifiers working as differential amplifiers.

The purpose of the amplifier stage is to increase the level of the signal entering the SAW filter 40. This technique increases the dynamic range of the tuner and enables the tuner to receive signals over a wider power level range.

The signal amplified by the amplifier stage 36,38 is then provided to a SAW filter stage. The SAW filter stage comprises a SAW filter 40 connected to a buffer amplifier 42 connected in turn to a variable gain amplifier 44 connected in turn to another SAW filter 46.

By virtue of this SAW filter and amplifier combination, the SAW filter stage has the function of filtering the IF signal so that only the digital TV signal is allowed to pass through subsequent stages in the presence of PALL TV signals in the adjacent channels as received by the tuner. A benefit of this is that an analogue to digital convertor 56, to be described later, with fewer bits can be used. For example, if only one SAW filter is used, as is the case with previous tuners, then an analogue to digital convertor with at least 10 bits would have to be used to achieve the same performance as an analogue to digital convertor of only 8 bits in the described circuit with a digital signal of the 2K constellation. 2K and 8K modulation modes are both possible with embodiments of the present invention.

A variable gain amplifier 48 is used to amplify the output of the second SAW filter 46. This forms part of a multiple automatic gain control (AGC) used through the tuner.

This means that the tuner carrier to noise figure can be maintained at a nearly constant value irrespective of the power level of the signal received by the tuner. The use of multiple AGC enables the dynamic range of the tuner to be greater than that of previous tuners.

The IF signal is passed from the variable gain amplifier 48 to a mixer 50 for down converting the IF signal to a lower IF signal for subsequent analogue to

digital conversion. The mixer is a ring diode type mixer such as mixer 30. This mixer is able to process higher levels of signal compared with previous devices and allows the dynamic range of the tuner to be increased compared with previous tuners.

The mixer 50 is controlled by a crystal oscillator 52.

The lower IF signal produced by the mixer 50 then passes to a low pass filter or diplexer.

The base band or lower IF signal generated from the mixer enters the diplexer 54 which maintains a constant impedance at the output of the mixer 50 whilst filtering out unwanted signals, such as side bands, generated in the mixer 50. The diplexer has the benefit of increasing the dynamic range of the tuner without having to increase the number of bits used in the analogue to digital convertor.

Finally, the base band signal is provided to the analogue to digital convertor 56 for further processing.

CLAIMS

1. A digital terrestrial TV tuner comprising:

an amplifier for receiving a UHF signal;

a voltage tunable bandpass filter for filtering the amplified UHF signal; and

a down conversion circuit for down converting the filtered UHF signal to an IF signal; the tuner further comprising:

a voltage controlled attenuator for attenuating the signal output from the amplifier and input to the voltage tunable bandpass filter.

2. A tuner according to claim 1 further comprising:

an input voltage tunable bandpass filter for bandpass filtering a received signal and outputting the bandpass filtered signal to said amplifier as the UHF signal.

3. A digital terrestrial TV tuner comprising:

a UHF to IF down conversion circuit; wherein the down conversion circuit includes:

a ring diode mixer for multiplying an input UHF signal with a down conversion signal to produce an output IF signal; and

a local oscillator for providing the down conversion signal.

4. A tuner according to claim 3 wherein:

the ring diode mixer is a passive diode ring double

balanced mixer.

5. A tuner according to claim 3 or 4 wherein the local oscillator is a low phase noise crystal controlled PLL synthesizer.

6. A digital terrestrial TV tuner comprising:

an input circuit for producing an IF signal from an input UHF signal;

an amplifier stage for amplifying the IF signal; and

a SAW filter stage for filtering the amplified IF signal; wherein

the amplifier stage comprises:

two series connected high gain amplifiers.

7. A tuner according to claim 6 wherein the two series connected amplifiers form a differential driver amplifier stage.

8. A tuner according to claim 6 or 7 wherein the tuner further comprises:

a low pass filter of predetermined cut-off frequency connected between the input circuit and the amplifier stage for filtering the IF signal provided to the amplifier stage.

9. A digital terrestrial TV tuner comprising an input circuit for providing an IF signal from an input UHF signal;

an amplifier stage for amplifying the IF signal; and

a SAW filter stage for filtering the amplified IF signal; wherein:

the SAW filter stage comprises:

a first SAW filter, a buffer amplifier, a variable gain amplifier and a second SAW filter connected in series.

10. A digital terrestrial TV tuner comprising:

an input circuit for providing an IF signal from an input UHF signal;

an amplifier stage for amplifying the IF signal;

a SAW filter stage for filtering the amplified IF signal; and

an analogue to digital convertor for processing a signal derived from the SAW filter stage; wherein

the tuner further comprises:

a mixer for down-converting a filtered IF signal derived from the SAW filter stage to a lower IF signal for conversion by the analogue to digital convertor.

11. A tuner according to claim 10 wherein the mixer is a ring diode type mixer.

12. A tuner according to claim 11 wherein the down-conversion signal for said mixer is provided by a crystal oscillator.

13. A tuner according to claim 10, 11 or 12 further comprising:

a variable gain amplifier connected between the output of the SAW filter stage and the input of the mixer for amplified the filtered IF signal provided to the mixer.

14. A tuner according to any one of claims 10 to 13 further comprising:

a low pass filter connected between the output of the mixer and the input of the analogue to digital convertor for low pass filtering the lower IF signal provided to the analogue to digital convertor.

15. A tuner according to claim 14 wherein the low pass filter is a diplexer.

16. A digital terrestrial TV tuner according to any one of the claims in any one of the groups of claims 1 and 2, 3 to 5, 6 to 8, 9 and 10 to 15 in combination with features from any one of the claims of any other of said groups.

17. A digital terrestrial TV tuner constructed and arranged substantially as hereinbefore described with reference to and as illustrated by Figure 2 of the accompanying drawings.

The Patent Office

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Application No: GB 9821187.3
Claims searched: 1,2

Examiner: D Midgley
Date of search: 18 December 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): H3G GCS H3Q QDRD,QDRS

Int Cl (Ed.6): H03D 7/16 H03G 1/00,3/20,3/30 H04B 1/26,1/28

Other: ONLINE:EPODOC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP 464792 A2	(TOSHIBA) See, for example, figure 3	1,2
X	EP 464670 A2	(SANYO) See, for example, figure 2	1,2
X	US 5175883	(PIONEER) See, for example, figure 1	1,2
X	US4520507	(ZENITH) See, for example, figure 1	1,2
X	US 4355414	(HITACHI) See, for example, figure 3	1,2

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

The Patent Office 16

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Application No:	GB 9821187.3	**Examiner:**	D Midgley
Claims searched:	3-5	**Date of search:**	24 June 1999

Patents Act 1977
Further Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H3R RMX H3Q QDRS QDRD

Int Cl (Ed.6): H03D 7/02,7/14 H04B 1/26 H04N 5/44

Other: ONLINE:WPI,EPODOC,JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2297446 A	(MARCONI) whole doc.	3-5
X	US 5428839	(MOTOROLA) whole doc.	"

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Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

The Patent Office 17

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Application No: GB 9821187.3
Claims searched: 6-8

Examiner: D Midgley
Date of search: 24 June 1999

Patents Act 1977
Further Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H3Q QDRS,QDRD

Int Cl (Ed.6): H04B 1/26 H04N 5/44

Other: ONLINE:WPI,EPODOC,JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	US 5523801	(MITSUBISHI) See, for example, figure 2, item 5	6,8
X	US 4410864	(RCA) See, for example, figure 1	6,8
X	US 4271433	(RCA) See, for example, figure 1	6
X	WPI Abstract Accession No. 95-121001 [16] and JP070046497 A (Sony) 14.2.95 (see abstract)		6

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

The Patent Office (8

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Application No:	GB 9821187.3	**Examiner:**	D Midgley
Claims searched:	9	**Date of search:**	24 June 1999

Patents Act 1977
Further Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H3Q QDRS QDRD

Int Cl (Ed.6): H04B 1/26 H04N 5/44

Other: ONLINE:WPI,EPODOC,JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
	NONE	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

The Patent Office 19

INVESTOR IN PEOPLE

Application No:	GB 9821187.3	**Examiner:**	D Midgley
Claims searched:	10-15	**Date of search:**	24 June 1999

Patents Act 1977
Further Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H3Q QDRD

Int Cl (Ed.6): H03D 7/16 H04B 1/26 H04N 5/44

Other: ONLINE:WPI,EPODOC,JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	US 5748262	(THOMSON) See, for example, figure 2 and the desciption thereof.	10-15

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.